Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	)	
Advanced Television Systems and Their Impact on the Existing Television Broadcast Service	)	
Review of Technical and Operational Requirements: Part 73-E, Television Broadcast Stations	)	MM Docket No. 87-268
Reevaluation of the UHF Television Channel and Distance Separation Requirements of Part 73 of the Commission's Rules	)	

COMMENTS
OF
THE DAVID SARNOFF RESEARCH CENTER, INC.

on the

TENTATIVE DECISION AND
FURTHER NOTICE OF INQUIRY

Released: September 1, 1988

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INTRODUCTION

The David Sarnoff Research Center, Inc. (formerly RCA Laboratories) is engaged in the design and development of improved and advanced television systems for the United States and therefore has a major interest in the issues raised by the Federal Communication Commission's (FCC) Tentative Decision and Further Notice of Inquiry (FNOI) in MM Docket No. 87-268, released September 1, 1988.(1)

Established in 1942 as RCA Laboratories and reorganized in April 1987 as a subsidiary of SRI International, the David Sarnoff Research Center (Sarnoff) continues to study ways to improve the U.S. television system and brings to its Comments views developed by it and its predecessor company over five decades of work. Sarnoff is involved in many aspects of the work of the Advisory Committee on Advanced Television Systems (ACATS), including service on its Subcommittees and Working Parties.

Sarnoff has developed Advanced Compatible Television (ACTV) under the sponsorship of NBC and RCA. It has been described in detail in previous Comments in this docket as well as in submissions to the Systems Subcommittee of ACATS. Advanced Compatible Television is an evolutionary system that can be introduced in a single 6-MHz channel in a receiver-compatible* manner. As such, it offers 16x9 aspect ratio with improved horizontal and vertical resolution. Compatibility is a fundamental tenet of ACTV. The effects on existing NTSC receivers of the introduction of ACTV will be even less noticeable than the introduction of compatible color was on black and white receivers of that day.

Sarnoff's proposed introductory system, called ACTV-I, will provide picture quality that is improved significantly over NTSC. The ACTV-I signal can be augmented to provide full HDTV quality by using additional

* Receiver-compatible, in this text, means that the same single-channel ACTV signal can be viewed on both NTSC and ACTV receivers. The NTSC receiver will produce a standard 4:3, NTSC-quality picture.

bandwidth. This augmented system is designated ACTV-II. It includes further picture resolution improvement and digital audio enhancements. This ACTV-II signal is fully reverse-compatible with ACTV-I receivers as well as with existing NTSC receivers. The additional bandwidth need not be contiguous to the main channel.

The evolutionary scenario above for the introduction and augmentation of Advanced Compatible Television is designed to match the time-changing realities of display performance and spectrum availability. ACTV-I offers the opportunity to improve TV pictures **now**. There is no need to wait for bright, high resolution, consumer-priced picture tubes or other advanced display technology, or for improved UHF tuners so that taboos can be relaxed to release bandwidth for improved TV. The evolutionary step to ACTV-II will bring full HDTV at the earliest possible time when the economics of picture tubes and the knowledge of interference effects on wide-band HDTV signals all coincide sensibly. Studies must establish co-channel and adjacent channel requirements in addition to UHF taboo performance for various combinations of Advanced Television (ATV) and NTSC signals before spectrum can be allocated. Completion of such studies will also form the basis for any future sharing of broadcast spectrum with other services.

With this Introduction to Sarnoff's background, interest, and expertise in the matters of this docket, the following comments are offered in response to the specific questions in this FNOI.

THE ADVISORY COMMITTEE'S INTERIM REPORT (¶5, ¶10-14)

Sarnoff applauds the efforts of the Advisory Committee and its creation of a comprehensive Report in a very short time. Sarnoff strongly supports the Commission's conclusions that compatibility with existing NTSC receivers is essential for any system that would be broadcast in the United States and that broadcasters must have the opportunity to deliver signals to their audiences that are the equal of signals available from other media.

The Advisory Committee believes that channels of more than 6 MHz are necessary to deliver competitive "HDTV" signals. This is actually a complex question involving television signal processing and the human vision system. HDTV source material requires a bandwidth that is typically 30 or 40 MHz. Every practical transmission system would compress such signals to a great extent, whether the final broadcast channel bandwidth be 6, 9, or 12 MHz. The means to achieve this compression (1) exploits the unique properties of the television baseband spectrum and the nature of human perception but (2) requires some reduction of information from the original HDTV source. The best systems offer maximum bandwidth reduction, make the least perceptible trade-offs, preserve compatibility, and minimize cost (especially of receivers). The performance of 6-MHz compatible systems, such as ACTV-I, must be evaluated by these criteria of spectrum efficiency, subjective performance, compatibility, and cost. Although more information (and, therefore, presumably better pictures) can be delivered if more bandwidth is devoted to the process, the performance of 6 MHz systems should not be dismissed lightly, nor should a minimum bandwidth be set arbitrarily as a requirement for "HDTV." Bandwidth is always a costly resource, whether the delivery medium be broadcast, cable, tape, satellite, or other means.

The Advisory Committee addressed the issue of availability of spectrum within the VHF and UHF television bands. It concluded that additional spectrum might be available, assuming that (1) the UHF "taboos" could be abandoned among ATV stations, (2) ATV systems could

operate at signal levels that cause little or no interference to existing NTSC, and (3) ATV systems could tolerate high levels of interference. These assumptions are tenuous. The impact on the existing NTSC receiver population of delivering signals containing non-NTSC modulation in previously taboo channels has not been determined. The power levels required to obtain satisfactory coverage by new ATV signals are unknown. While modern signal processing techniques can achieve great ruggedness and very high bandwidth compression, these two goals usually work in opposition to each other. The assumed ruggedness of ATV combined with the required bandwidth reduction has not been proven. For these reasons, Sarnoff urges caution in assuming the early availability of sufficient additional spectrum for ATV. This same caution applies to other possible uses of TV broadcast spectrum. Assertions that other signals will not cause interference to NTSC are unproven. Their effect on ATV signals cannot be known until the ATV signals are defined and tested. Broadcast spectrum must not be re-assigned for other uses until these fundamental questions of signal compatibility and ATV requirements have been tested.

SPECTRUM ISSUES

Sarnoff considers the priorities set forth by the Commission (¶82) regarding the importance of spectrum efficiency to be correct and necessary. As the Commission states, maintenance of NTSC service is a necessary requirement, and the provision of an additional 6 MHz should be sufficient for a new service. Data[3] show that even 3 MHz of additional bandwidth will be difficult to provide in some major markets. Systems requiring more spectrum than this are impractical for terrestrial broadcast and should be eliminated from consideration. In pursuit of spectrum efficiency, the Sarnoff ACTV-I proposal fits within a **single** 6 MHz channel, provides wide aspect ratio and improved resolution over NTSC, and can serve until additional spectrum is available for all broadcasters.

Spectrum Assignment Options

Sarnoff believes that a sound decision on the amount of additional spectrum to assign to ATV (¶83) is impossible to make at this time. No system meeting the Commission's spectrum efficiency requirements has been tested to date, although a variety of proposals exists. The subjective effects of the different trade-offs in bandwidth and video fidelity embodied in these proposals have not been evaluated. Likewise, a single incompatible channel capable of delivering full HDTV within 6 MHz has not been demonstrated. **Therefore, Sarnoff urges that decisions about additional spectrum be deferred until the ATV system testing process already under way is completed. Sarnoff further urges that the existing VHF and UHF broadcast spectrum be preserved for ATV for the duration of these studies.**

Sarnoff notes that the Commission has taken a bold, but well-considered, step in its tentative decision to abandon the microwave frequencies for ATV transmission, thus limiting the search for ATV spectrum to the present VHF and UHF broadcast bands (¶154). Without further testing, this is as great a step as prudence will allow. The

assumptions that taboos can be relaxed must be tested. The amount of additional spectrum each system will require (3 MHz or 6 MHz) must be established by tests. The interference performance of the new HDTV signals must be determined. The Advisory Committee has already initiated a testing process to resolve these questions. Sarnoff urges that the Commission resist pressure to make hasty decisions about assignments until the results of the Advisory Committee's tests are complete. Sarnoff further notes that much difficult work remains for the Commission's ATV Subcommittees.

The Commission has provided a cogent summary of the advantages of a 6 MHz compatible ATV system (¶84-86). Sarnoff has come to similar conclusions and so has developed its ACTV-I system. As the Commission has stated (¶85), such a 6 MHz NTSC-compatible ATV system would likely allow a more rapid transition to ATV than would otherwise be possible. Furthermore, as discussed in the comments and the economic analysis of the Advisory Committee's Working Party 5 (WP5) as well as by the Commission (¶84), "a 6 MHz compatible ATV system is expected to have only a relatively small economic impact on broadcasters, cable operators, and consumers." As the Commission has also stated (¶86), the quality of ATV service provided within 6 MHz will not be as high as that possible with more bandwidth, although the qualitative improvement and the value that customers will attach to the improved performance is not known. Sarnoff agrees that it is not clear that broadcasters can remain competitive for the long run with bandwidth allocations limited to the present 6 MHz (¶86); Sarnoff offers ACTV-II as an augmentation channel when spectrum becomes available, should it be needed for broadcaster competitiveness. **Sarnoff urges that no non-broadcast use of the UHF band (¶84) be considered until these matters are resolved.**

The allocation of additional spectrum (¶87-91), whether 3 or 6 MHz, requires careful test. Despite the willingness of the Advisory Committee in its Interim Report to assume that the UHF "taboos" could be abandoned among ATV stations and that interference to NTSC and new ATV systems could be held to tolerable levels, Sarnoff urges caution in creating policy based on these assumptions. The video performance of the proposed ATV

systems has not been ascertained nor has their tolerance of interference. The tolerance of (possibly nearby) existing receivers to these new, non-NTSC, signals, however weak, has not been determined. The hope that a single, incompatible, 6 MHz signal can deliver full HDTV has not been tested either. Should such systems work, they offer the possibility of returning the spectrum used by NTSC broadcasts **someday** (¶89), Sarnoff notes that monochrome receiver sales still continue some three decades after the advent of compatible color and suggests that this fact may be instructive for assumptions about the future sales of NTSC receivers. The end-of-life of as-yet-unsold NTSC receivers is decades in the future. There will be no foreseeable opportunity to re-assign the frequencies of the present NTSC channels.

Sarnoff does not see overwhelming technical difficulties in using supplemental spectrum where there are large differences in frequency between primary and supplemental channels (¶88). Adjacent channels would likely be easier, but the problems of noise, interference, and multipath can be addressed. Workable proposals for multipath reduction or cancellation at the receiver exist, including a system developed by Sarnoff. Noise and interference control depend on delivery of adequate signal strength to the receiver. This can be accomplished by the combination of adequate numbers and power levels of transmitting stations and use of better receiving antennas where necessary. However, Sarnoff believes that supplemental spectrum authorization (¶90) must be postponed until completion of the Commission's studies.

The Commission invited comment on its four options for spectrum assignment (¶83). Sarnoff suggests modifying the wording of the augmentation options (2 and 3) to include possible augmentation of an NTSC-*compatible* ATV signal (option 1), such as the Advanced Compatible Television system proposed by the David Sarnoff Research Center. The four modified options become:

1. No additional spectrum allotment.

2. 3 MHz additional spectrum not necessarily contiguous to augment existing NTSC signals or NTSC-compatible ATV signals requiring no additional spectrum (option 1).
3. 6 MHz additional spectrum not necessarily contiguous to augment existing NTSC signals or NTSC-compatible ATV signals requiring no additional spectrum (option 1).
4. 6 MHz of additional spectrum not necessarily contiguous for transmission of a non-compatible "stand alone" ATV.

In view of the Commission's requirement for compatible ATV broadcast (¶82), Sarnoff assumes that option 4 is intended exclusively for ATV simulcast of programs that can also be received on a current NTSC receiver at the same location as the ATV receiver. Otherwise, if ATV channels contain different programming, compatibility has been effectively defeated.

Sarnoff believes that, for the present, no system requiring additional spectrum (options 2, 3, 4) is a viable option. There are two reasons for this opinion. First, spectrum availability studies are still in an early phase and must progress much further before it can be established whether any system requiring additional spectrum can provide a viable ATV service to the majority of TV homes. Second, although numerous such systems have been proposed, none has been tested under the realistic transmission conditions imposed by an allocation plan restricted to the VHF and UHF TV broadcast bands. Even the preliminary studies indicate that the effective radiated power of these supplemental signals must be significantly weaker than the power radiated by current TV stations, i.e., the proposed ATV signals must deliver high quality signals in the presence of rf noise and interference from existing high power TV stations. The proposed ATV options 2, 3, and 4 have not been tested for the robustness that a VHF-UHF band allocation plan requires.

With regard to repackaging, (¶92-93), Sarnoff suggests that the effects of repackaging should be part of future studies. It is unclear at this time whether minor repackaging could significantly contribute to more spectrum for ATV.

The cost and benefit analysis of ATV (¶91) is a complex undertaking. Sarnoff reserves comment pending review of the data collected by the Advisory Committee.

Studies Related to Spectrum Availability for ATV

Commendable preliminary studies of the availability of spectrum for advanced television systems have been made by Working Party 3 (WP3) of the Advisory Committee on Advanced Television Service[2] (ACATS), by the technical staff of the Federal Communications Commission[3],[4], and by other parties[5],[6],[7],[8],[9],[10]. Sarnoff emphasizes that these studies are, and do not claim to be anything but, **very preliminary;** without further effort, they are not reliable predictors of viable spectrum scenarios, nor are they a basis for spectrum allocations.

In order to make even preliminary comments in the face of unknown and complex technical factors, the studies use many simplifying assumptions to consider the feasibility of providing a significant fraction of existing television broadcast stations with 3 or 6 MHz of supplemental UHF or VHF TV spectrum for ATV. The results are inconclusive. **Much work remains before a meaningful technical basis can be formed for spectrum allotment for ATV or other uses of the UHF and VHF bands. For this reason Sarnoff urges the Commission to use great caution in proceeding with spectrum decisions (¶94,96,155).** The studies form a good start for continued work in that they have exposed the complexities of the spectrum issues and identified relevant technical and legal factors and problems. The Commission should encourage the Advisory Committee, the FCC staff, and other parties to continue diligently the analytical and experimental work required to obtain a basis for informed spectrum decisions.

The preliminary studies[2,3,4,5,6,7,8,9,10] indicate that it is unlikely that all existing TV broadcast stations, particularly those in the major markets, can be provided with additional 3 MHz or 6 MHz of spectrum for

ATV. Table 1 and Table 2 in this FNOI, derived from the FCC-OET study[3] (which assumes only co- and adjacent-channel restrictions and no UHF taboo restrictions), indicate that, with a co-channel separation of 190 miles (required in Zone II VHF spectrum, FCC rules §73.610), the percentage of existing stations that can be accommodated nationwide is 77% and 61% for 3 MHz and 6 MHz of supplemental spectrum, respectively. In the major markets, this study shows that no stations in New York City or in Philadelphia and only two stations in Chicago and five in Los Angeles can be accommodated.

All the preliminary studies clearly indicate that the effective radiated power of any supplemental ATV signals must be substantially lower than that of existing stations. How much lower the effective radiated power must be for co-existence with the existing NTSC service and how much lower it can be to provide ATV service with acceptable quality is a key unresolved question. The answer depends on the as-yet-unspecified nature of the radiated supplemental ATV signal.

All estimates made thus far[2],[3],[6] of the fraction of existing stations that could be accommodated with supplemental 3 and 6 MHz spectrum are based simply on the assumption that the locations of co-channel and adjacent channel stations must be separated spatially from the desired channel by a certain number of miles. Even with these simplifying assumptions, the calculations are by no means trivial; they are a good initial approach to an estimate of ATV coverage, but they are probably the simplest part of the studies that must be made.

Additional studies must determine the electromagnetic fields at all receiver sites (TV homes) for various allocation scenarios over the VHF and UHF bands. A constructive step in this direction has been taken in the FCC-OET spectrum study (TM88-1)[3]. Appendix C in that study contains tables relating the distance between stations to the ratio of the field strengths of desired to undesired TV signals (referred to as the D/U ratio) at some receiving site along a line between the two stations. It is assumed (although not stated specifically in the OET study) that these charts are determined from the FCC field strength charts (FCC rules §73.699 figure 9

and 10) using the FCC (50,10) charts (field strength exceeded at 50% of the locations 10% of the time) to determine the undesired signal and the FCC (50,50) charts to determine the desired signal.

While the FCC charts and the underlying database are useful, Sarnoff suspects that further field strength experiments may be required to refine this database, since ATV would entail a significant increase in the crowding of the spectrum. In the meantime, current FCC field strength determinations [FCC(50,10) and FCC(50,50)] and the FCC database of spectrum allocations can be coupled with the demographics of TV households to estimate D/U ratios for co-channel, adjacent channel and taboo channel interferences as a function of various ATV scenarios. By inclusion of demographics, such a study could determine the number of homes where various types of D/U ratios are exceeded for some given area, e.g. the entire country, a city, strong and weak signal areas, areas inside the grade A or B contours, etc. Such a statistical analysis is necessary and would represent a significant improvement over the results of present studies. This analysis could later be refined with the improved experimental field strength data.

The studies by Rypkema[7],[8],[9],[10] and by Jansky-O'Connor[5] indicate that significant improvements in D/U ratios with regard to interference from UHF taboo channels could result from co-location of taboo channels with desired channels. If this conclusion is correct, and it appears to be, the taboo channel constraints[13],[14], which are now expressed in miles of separation from the desired stations, should be revised and replaced by a more sophisticated allocation algorithm based on acceptable D/U ratios at various signal levels.

The remaining key issue is determination of acceptable D/U ratios (as a function of the desired signal level) for co-channel, adjacent channel, and taboo channels for compatible reception with existing and future NTSC receivers as well as for high quality reception with future ATV receivers. Some recommendations of D/U ratios have been made by the CCIR[12] for co-channel and adjacent channel interference for the case when the signals in both channels are standard vestigial sideband AM color

television signals. CCIR recommends D/U ratios for just tolerable impairment of 28 dB for interference by a co-channel with standard (but not precise) frequency offset and about -10 dB for interference by an adjacent channel. Present FCC allocations, intended to provide acceptable reception out to the grade B contour, conform quite well with these recommendations.

With regard to improving the tolerance (or reducing the required D/U ratios) of NTSC receivers to interference from taboo channels (¶69-72,81), Sarnoff refers to its own comments(11) (pages 20 to 25) submitted 11/17/87 to the Commission in response to the NOI (Docket 87-268). Sarnoff advised the Commission that receivers that are more tolerant to taboo channel interferences than present receivers can be designed. In those comments, Sarnoff included a section on potential receiver improvements containing a list of technologies that could be applied to achieve a taboo-robust tuner design. This section was also included as an appendix in the Jansky-O'Connor report. Sarnoff cautioned the Commission about the time frame and the cost to the public for a significant penetration of taboo-robust receivers in TV homes. This time frame can be divided in three phases: (1) a study phase to determine how and which taboos could be modified to improve spectrum efficiency and with what cost and performance trade-off, (2) a receiver design and manufacturing phase, and (3) a phase for penetrating the field with taboo-robust receivers. Sarnoff believes that this time frame is of the order of at least ten years.

Sarnoff believes that future ATV receivers can be designed to be substantially more taboo-robust than existing TV receivers. Nevertheless, at some signal level some taboo signals may cause a disturbance in the best of receivers. Sarnoff is more cautious than the Commission in its belief (¶81) that it is technically and economically feasible to design ATV systems and receivers that are absolutely immune to NTSC UHF taboo interference.

The interference from an ATV signal in a taboo channel may be very different from the interference caused by a standard TV signal in the same

taboo channel. Measurements must be made to determine tolerable levels of disturbances by ATV signals. As a consequence, in the first study phase of a program to develop taboo-robust receivers, assumptions must be made about the nature of ATV signals. As Rypkema[7],[8],[9],[10] clearly shows, the interferences caused by different taboo signals may be caused by different mechanisms. Thus the D/U ratios of taboo signal interferences may not be the only parameter having bearing on a spectrum allocation plan.

In summary, while commendable preliminary studies have been made on spectrum availability, many unresolved issues remain. One of the most critical is the nature of the ATV signal that will be broadcast in the supplemental frequency bands. **For this reason, Sarnoff urges the Commission to postpone spectrum decisions until after the Advisory Committee has completed tests on proposed systems and presented proposed system standards in the context of completed studies of spectrum availability (¶94).** Sarnoff further recommends continued effort in the following areas:

1. Develop computer programs to determine D/U ratios for undesired co-channel, adjacent channel, and taboo channels in strong and weak signal service areas for various ATV spectrum and effective radiated power allocation scenarios, given the current FCC field strength estimates and station allocation database.

2. In connection with the above study, assess the effects of co-locating taboo channels with desired channels.

3. Add receiver demographics to the above studies to determine how many TV homes in a given area (the entire country, major markets, within the grade B contour, etc.) can be accommodated compatibly with an acceptable ATV service requiring additional 3 or 6 MHz of VHF or UHF spectrum.

4. On the basis of the above studies, explore trade-offs between compatibility and ATV quality and coverage.

5. Explore the effects of the introduction of NTSC and ATV receivers that are more tolerant to interferences in various taboo channels.

6. In cooperation with receiver manufacturers, develop a plan and a timetable for modification of some of the taboos, particularly in connection with ATV allocations.

7. Study co-channel, adjacent channel and taboo channel interferences of proposed ATV signals into existing and future NTSC and ATV receivers.

8. Explore the effects of precise frequency offset.

9. Explore the effects of improved receiving antennas on D/U ratios and signal-to-noise ratios in ATV reception and the resulting effects on ATV spectrum assignments.

10. Determine whether better antennas at some currently critical NTSC receiving sites may be required to provide increased ATV coverage. Review planning factors in the context of new technologies and better antennas.

11. Explore the effects of minor repackaging of VHF-UHF allotments of spectrum.

12. Develop measurement procedures and make measurements of ATV interferences in NTSC receivers and vice versa.

13. Make field strength measurements to validate and refine current FCC radiation propagation data.

14. On the basis of the above studies, develop a new FCC station allocation algorithm for the UHF and VHF spectra, accounting for all technical, legal, and demographic factors in these proceedings.

Timetable for Future Action

Sarnoff supports the desire for as rapid a timetable as possible (¶94), but argues strongly against overly hasty spectrum proposals made before technical standards issues have been resolved. Wise frequency allocations are impossible before the nature of the signals to be transmitted has been defined. There is no need to propose allocation plans to narrow the number of systems under consideration -- the Commission has already done this by its correct prioritization of spectrum efficiency. The Commission has established a process for characterizing the performance and spectrum requirements of proposed systems; Sarnoff urges that this process be carried to completion without the unnecessary distraction of premature spectrum proposals. Until the characterization process is finished, broadcast spectrum must be preserved so that necessary alternatives are not foreclosed. Sarnoff believes that the Commission cannot expect informed public comment (¶155) on allotment plans until the performance, spectrum, and interference requirements of ATV have been determined. Sarnoff further believes that it is not in the public interest to relax the freeze on television assignments or to consider non-broadcast uses of broadcast spectrum (¶155) until enough information is available to make informed comment possible.

UHF Freeze and Private Land Mobile Sharing

As the Commission clearly recognizes (¶96), spectrum sharing with private land mobile radio service (PLMRS) vastly complicates the spectrum issues and severely limits spectrum in the UHF band now designated for ATV. The preliminary study by the FCC staff[3] shows that the VHF and UHF spectrum may not be sufficient to accommodate all present stations with ATV; sharing this spectrum with PLMRS may crowd the spectrum to such extent that a viable ATV system requiring additional spectrum is no longer a possibility.

Sarnoff urges the Commission to refrain from new spectrum allocations for PLMRS, low power TV, or other non-ATV uses (¶91) until the spectrum studies previously mentioned have been completed and algorithms for a new spectrum allocation plan have been developed. Sarnoff also notes that low power TV stations at this time are permitted to broadcast double sideband AM (FCC rules §73.682 and §73.699 figure 5a), thereby using almost twice the spectral bandwidth of a standard high power station.

Sarnoff disagrees with the Commission's tentative recommendation that temporary permits could be issued for transmission of non-TV signals and low power TV signals in the TV bands before the new ATV allocation plan is completed. Sarnoff's concern is over the difficulty of revoking such temporary permits in the future.

Relay Services

The transmission of ATV over television relay links (¶97-102) will involve substantial changes from current practice. This is because infrastructure links such as satellite, AML and STL must support inherently wider band ATV signals with better signal-to-noise and distortion performance than for existing NTSC delivery. This is clearly true for 9 or 12 MHz ATV emission formats (such as MUSE[16], NYIT[17], MIT-RC[18] or PhilipsNA[19]). In addition, even 6 MHz channel compatible emission formats (such as Sarnoff ACTV-E[15], ACTV-I[15] Zenith[20] or MIT-BE[18]) contain signals that are likely to be incompatible with the bandwidth and signal modulation techniques used for FM-based video relay services (i.e., satellite & STL).

Thus, with the exception of ATV formats originally intended for satellite channels (such as MUSE or HDMAC60[19]), it will generally be necessary to transcode the ATV emission formats to ATV relay formats that are suitable for FM delivery. The relay format for FM transmission should be chosen on the basis of the following criteria: (1) ease of

conversion from or to studio ATV format, (2) ease of conversion to emission ATV format, (3) low susceptibility to non-linear signal distortion, and (4) good signal-to-noise performance.

Sarnoff is currently developing appropriate transcoding formats for FM relay of Advanced Compatible Television signals. Work to date shows that for Advanced Compatible Television (as well as other 6 MHz emission formats), the bandwidth of the transcoded signal for relay will exceed the nominal 4.2 MHz baseband bandwidth of NTSC video. It is envisioned that relay for ACTV-E[15] could be accomplished with either Wide Screen (WS) NTSC or a suitable time-multiplexed analog component (MAC) format with baseband bandwidths of about 6.5 MHz and 8.5 MHz respectively. Further evolution to ACTV-I and ACTV-II[15] would be supported with appropriate MAC formats with baseband bandwidths of the order of 10 and 12 MHz respectively. Other 6 MHz ATV emission proposals will also occupy substantially more than their nominal bandwidth when transcoded for relay. For example, the MIT-BE system may occupy ~12 MHz baseband bandwidth after appropriate transcoding. With regard to wider band ATV emission formats such as MUSE, PhilipsNA and NYIT, the typical FM relay signal baseband bandwidth will also be in the range of 9-12 MHz.

The above considerations lead to the following conclusions for each of the relay media alternatives:

Amplitude Modulated Link (AML): Existing 6 MHz AML channels (as in the 12.7-13.2 GHz CARS band) will require re-allocation unless 6 MHz channel compatible emission standards are adopted. This implies a need for the allocation of new frequencies in new frequency bands (such as 17-19 GHz) for ATV relay. Sarnoff believes that the technical problems involved with AM relay in these bands can be solved to provide adequate service.

Studio-to-Transmitter Link (STL): Existing 17 MHz STL links are not expected to support most ATV formats after

transcoding for FM delivery, unless the signal under consideration is readily transcodable to a bandwidth efficient FM relay format (such as Wide-Screen NTSC planned for use in ACTV-E delivery). Similarly, STL channels that operate in 24 MHz are expected to be limited by low FM deviation, resulting in loss of signal-to-noise and/or link margin. Sarnoff believes that ATV may eventually require reallocation of wider STL channels (possibly ~36 MHz), both in the existing 2 and 6 GHz bands as well as in new bands in the 17-19 GHz region. Channels at the higher frequency bands could be used for shorter distance applications.

Satellite links: Current satellite delivery systems to cable head-ends and affiliate stations typically employ one 36 MHz C-band or 54/72 MHz Ku-band satellite transponder per video channel. While ATV delivery with two transponders is obviously technically achievable, it is expected that cost considerations (if not the supply situation for transponders) will favor the use of a single transponder. For formats such as ACTV-E, ACTV-I and MUSE (with relay signal bandwidth under 9 MHz), it is expected that a single transponder will suffice, while for 12 MHz transcoded bandwidth (as for MIT-BE or ACTV-II), it is likely that two transponders will be required. For 9 MHz cases such as ACTV-I, smaller C-band stations, which currently have minimal link margins, may have to retrofit with a larger antenna to offset the loss in FM deviation. On the other hand, many Ku-band stations could operate without larger antennas since current practice is often based on partial bandwidth operation with large rain margin (thus permitting higher FM deviation for ATV). For the power and bandwidth limited 24 MHz DBS satellite scenario, reception of wideband ATV signals will require a significantly larger home antenna than for NTSC delivery. This difficulty suggests consideration of wider-band BSS transponder channels for future DBS service in the United States. A second approach (which has been employed in the direct-broadcast of MUSE) is to use a

combination of signal pre-filtering, pre-emphasis, FM overdeviation and relaxed transmission standards to achieve acceptable DBS signal quality and SNR.

Non-spectrum media: In view of the increased bandwidth requirements anticipated for STL and AML links, the congestion situation in metropolitan areas may be expected to worsen, even after new bands are identified. With the increasing penetration of fiber optic networks in urban areas, common carrier facilities will provide an alternative relay medium for (non-mobile) point-to-point applications. Typically, use of the common carrier facilities will require transcoding to an appropriate digital ATV format (such as the evolving 140 Mbps HDTV standard). This relay option, which is contingent upon increased local-area fiber-optic penetration and cost-effective analog to digital transcoding equipment, is expected to become a viable substitute for many STL users during the next decade.

ATV STANDARDS

Establishment of Standards (¶122):

(1) Sarnoff believes that the Commission should establish a single standard for delivery of ATV signals to home television receivers.

This action will result in the most rapid development and acceptance of ATV equipment, particularly in the consumer marketplace. It will allow the most cost-effective receiver designs. It can protect the performance of existing NTSC equipment and thereby the audience for initial broadcasts of ATV programming.

Sarnoff understands the Commission's desire (¶115) to allow future development of even better ATV systems but urges that arguments for flexibility not be used to preclude the benefits of standard-setting now. The process of review that precedes new or modified standards assures that compatibility issues will be studied thoroughly now and in the future and that the interests of the American consumer will be protected. The present study by ACATS of ATV and the former developments of multichannel sound and compatible color are testimony that flexibility is possible within an environment of standards. Sarnoff's Advanced Compatible Television proposal provides built-in flexibility by including compatible up-graded performance as soon as spectrum and display technology permit.

The Commission discusses relaxing or repealing the NTSC standard (¶106-108). Sarnoff believes that **compatibility** is the central issue of discussion and that slight modifications to the NTSC standard that preserve compatibility are possible. The intent of any modifications is to allow maximum use of the existing NTSC spectrum to deliver Advanced TV. This means that the broadcast industry can be satisfied that its existing audience will remain intact and that receiver designers can continue to work to a defined standard for the radiated signal and an expected ratio of desired-to-undesired signal strengths. Any

modifications must be tested and approved by the Commission and should not be left to the whims of local operators.

(2) Sarnoff agrees with the Commission that it is too early to adopt transmission standards.

The Commission has established the Advisory Committee to review and test ATV proposals. The work of this Committee should result in a recommendation of a system and a standard. The Commission's requested "benchmark" could be found in the completion of the testing and spectrum studies and the emerging of a consensus among the industry. Future ATV developments will continue. Their adoption at some future date will depend on their performance and their compatibility with NTSC (if owners of NTSC equipment still must be protected) and with whatever new standard the Commission selects as a result of its present inquiries.

(3) A **de facto** standard, set without the Commission's formal participation, is less likely to be in the public interest than one derived from the process urged in the preceding paragraphs.

Such a standard is likely to result in consumer confusion and broadcaster uncertainty. The short-term beneficiaries are likely to be manufacturers of self-contained video equipment (e.g., unified video tape and display devices) that could offer video quality broadcasters could not match without the Commission's action to set ATV transmission standards. Broadcasters and the American public will both suffer if broadcasters are relegated to the status of deliverers of inferior video.

(4) Sarnoff urges that the Commission select a **single** standard for ATV transmission to homes so that its development and acceptance will be most rapid. The complete system should be fully protected.

(5) Sarnoff believes that an open architecture receiver is neither a cost-effective nor soundly engineered approach to a consumer product and that its technical possibility should not become an excuse to avoid the difficult process of system selection and standard setting. Instead of

expensive open architecture, Sarnoff urges that a receiver interface standard at the RGB- or YIQ-level be defined; this approach allows interconnection of new video devices while allowing the receiver signal processing to be optimized for a single format.

Open architecture envisions plug-in hardware or software modules to re-configure a receiver for a variety of input signals. Technical and engineering questions include: reliability of the plugged connections; safety aspects of such interconnections in a box that might be opened by the consumer; (advance) determination of a suitable power supply to accommodate an unknown set of modules; RFI control when a sensitive tuner is incorporated in the very same box as the modules from a variety of manufacturers; and exactly what display capability is appropriate when the receiver circuitry is unknown.

The model for this "open" architecture seems to be home computers. This model is inappropriate for television because: the technically knowledgeable consumers who configure their own computers are willing to accept the difficulties of combining hardware and software from a variety of sources, but these computer-users are **not** typical of television purchasers; configurable home computers are not in the same cost-per-function league as television sets.

It is essential that, from the time of its introduction, a new consumer product be as unconfusing to buy, as simple to use, and as inexpensive as possible. Open architecture fails all three of these criteria because it requires the purchase of combinations of modules, envisions consumer-installed upgrades at later dates, and demands more expensive "host" boxes. It also creates consumer confusion about transmission standards and how to use the new service. Confusing, complicated, and expensive consumer products are unlikely to be successful.

There are also lost opportunity costs imposed by failure to specify a transmission format and the associated requirement for an open architecture receiver. If the transmission format is unconstrained, then receivers must provide functionality to handle new and unknown

modules. If new modules are to fit, a fixed bus structure would be imposed on receivers, limiting the opportunities for cost reduction. This is in contrast to design evolution in consumer products, whereby performance and cost trade-offs are made constantly so that the product can evolve. The consumer benefits more from a fixed transmission format and a flexible receiver design than from the opposite scenario imposed by open architecture. Examples of past design evolution include power supply simplification based on the changing requirements of the signal processing circuits and the invention of ways to share the power supply and deflection functions (these techniques are based upon fixed and known deflection requirements); other examples include filter cost reduction based on performance trade-offs and new technology.

No other product has achieved the price performance of TV, radio, and audio products. Sarnoff submits that this is because the design of such products has been honed to a known standard, which has allowed succeeding product generations to make smart engineering trade-offs that have benefitted consumers. Absent a standard, with a requirement of a rigidly specified receiver, the opportunities for the traditional and dramatic cost reductions of consumer electronics will be much reduced. Sarnoff urges that the Commission not avoid making a hard choice among systems by inflicting the costs of rigidly specified receivers on consumers.

(6) Sarnoff does not believe that an announced limited duration to a mandatory standard would serve the public interest. It would be confusing to consumers and would lead to deferment of purchases and slower growth of ATV. As in present and past circumstances, when technology warrants, new, compatible, standards can be adopted.

Compatibility with NTSC Receivers (¶125-126):

Sarnoff agrees with the Commission's concern for preservation of good broadcast service to owners of NTSC receivers. In this spirit, the questions of ¶126 are addressed: